Timestamping optical photons with Timepix3

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https://www.tpxcam.org

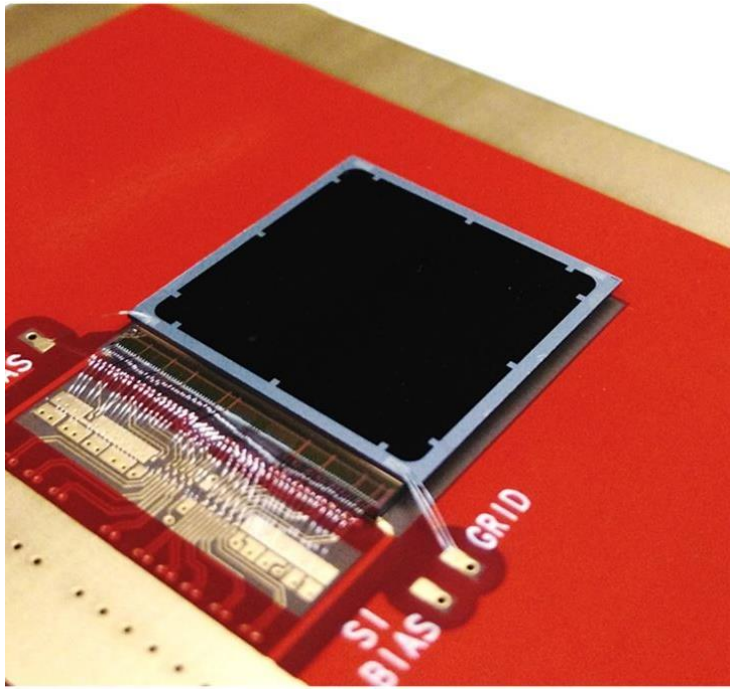
Overview

- Timepix detectors
  - Light sensitive sensors for TPX chips
- Different applications
  - Single photon detection
  - Ion detection (Velocity Mapping)
- Tpx3Cam
  - Applied corrections
  - Results

DEVICE DESCRIPTION

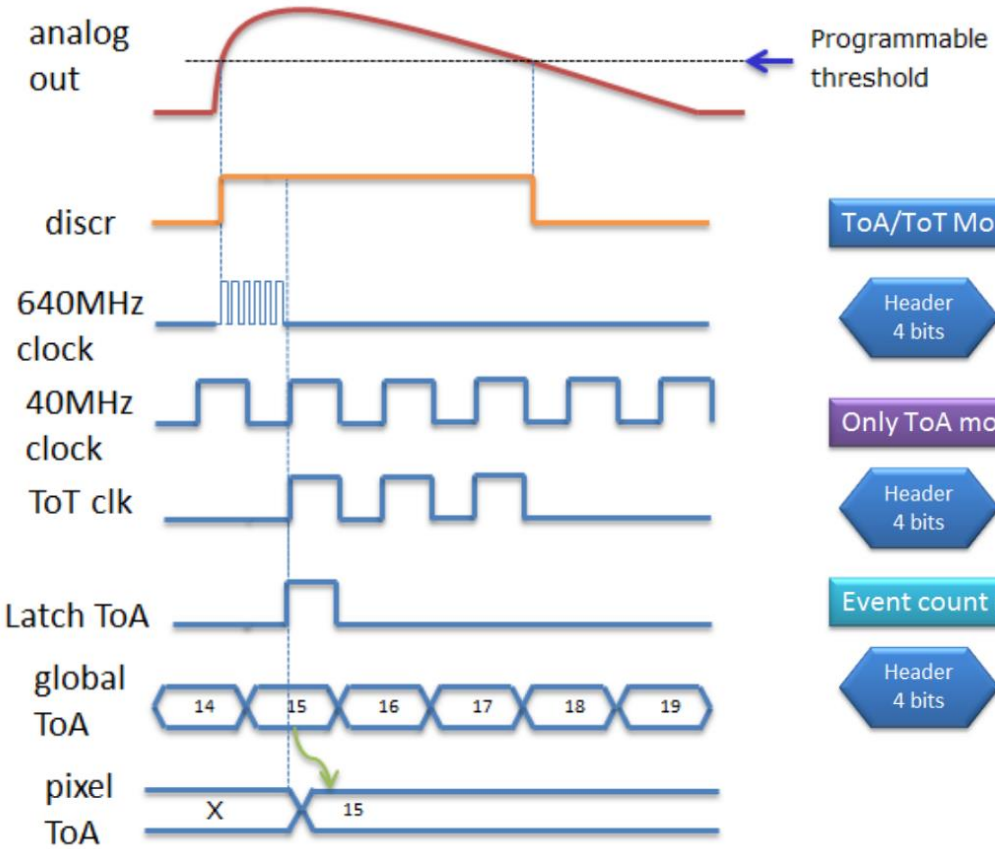
Timepix3 detector

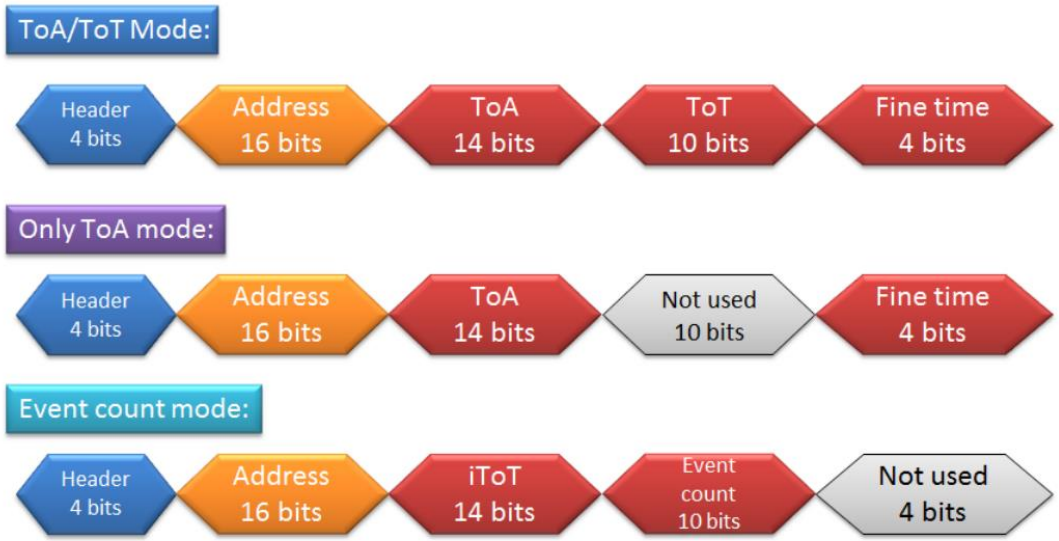
- Hybrid pixel detectors
- CERN collaboration
- Ongoing development of new devices



Pixels	256x256
Pixel size	55x55 μm^2
Dead time	ToT Pulse time + 475 ns
Timing resolution	1.5625 ns (640 MHz)
Acquisition modes	Charge and time Time only Counting and integral charge

Data format



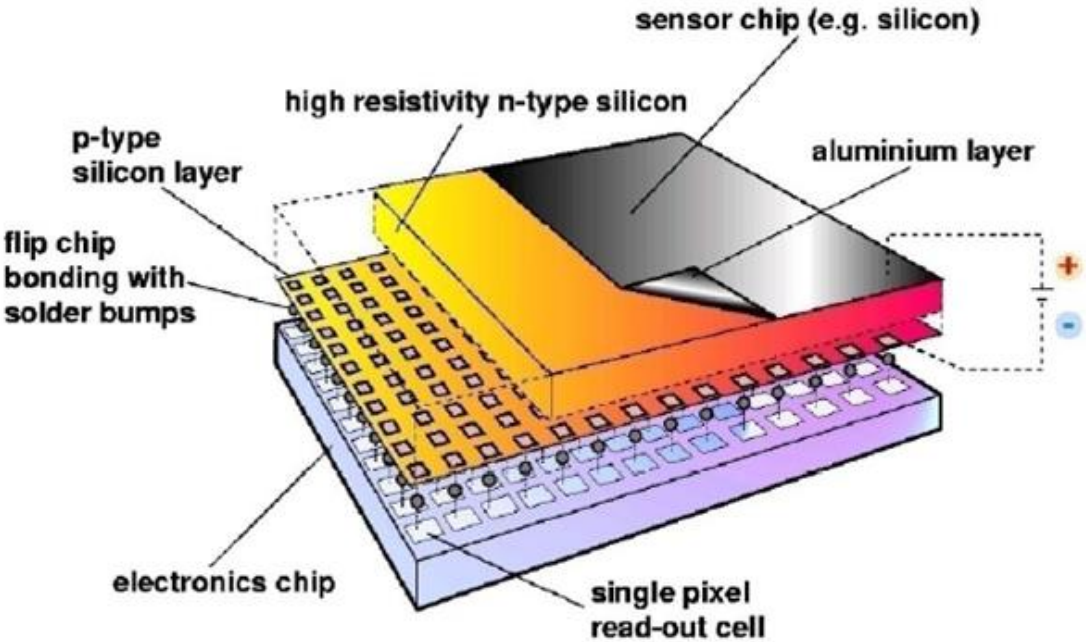


Timepix3: a 65K channel hybrid pixel readout chip with simultaneous ToA/ToT and sparse reado

T. Poikela, J. Plosila, T. Westerlund, M. Campbell, M. De Gaspari, X. Llopart, ...

Journal of Instrumentation 9, C05013

Hybrid detector cross section



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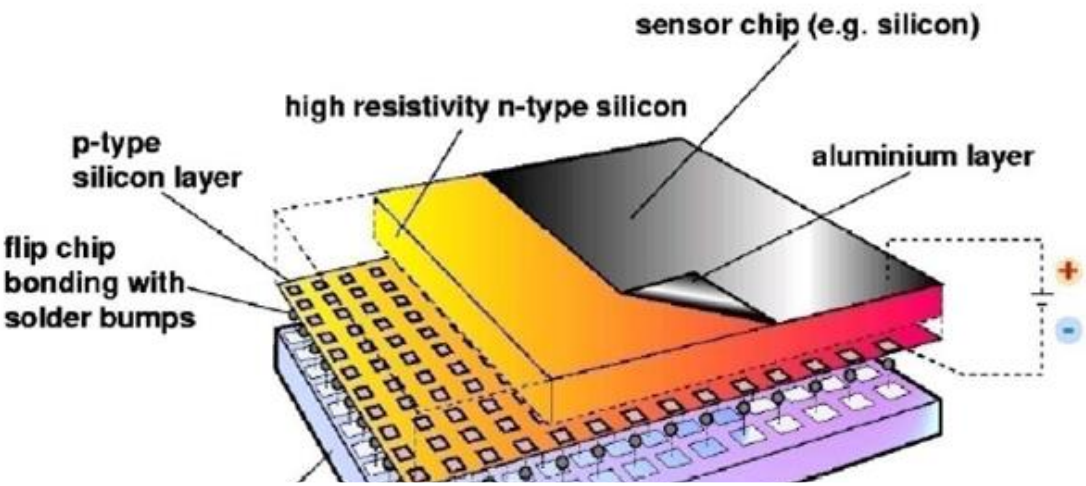

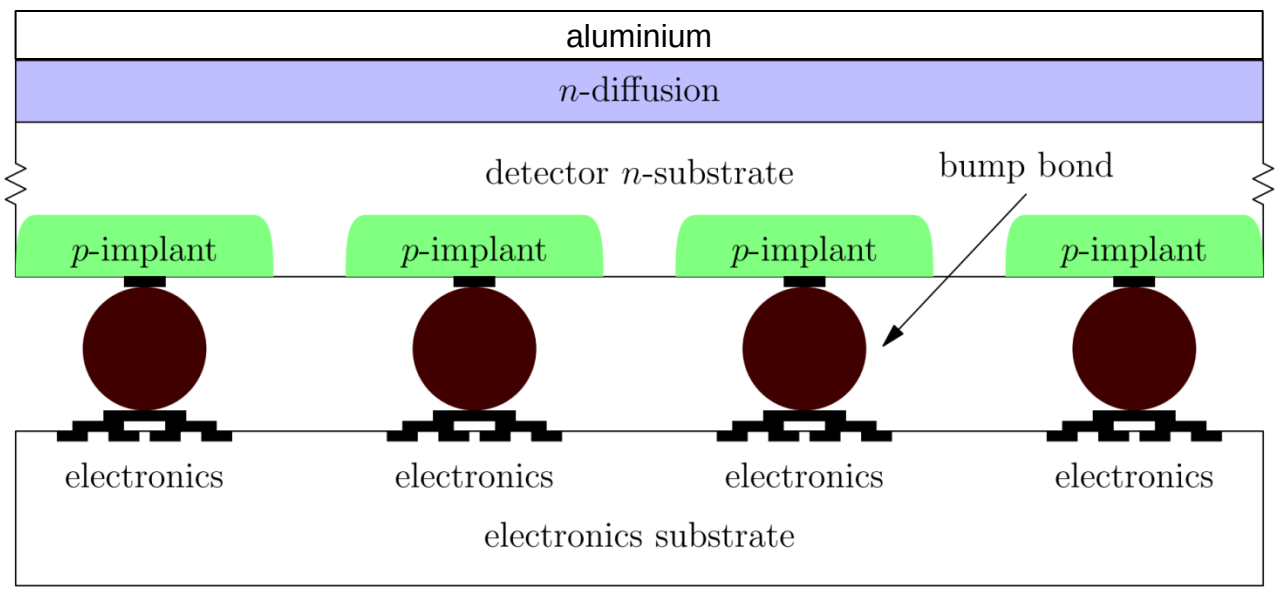

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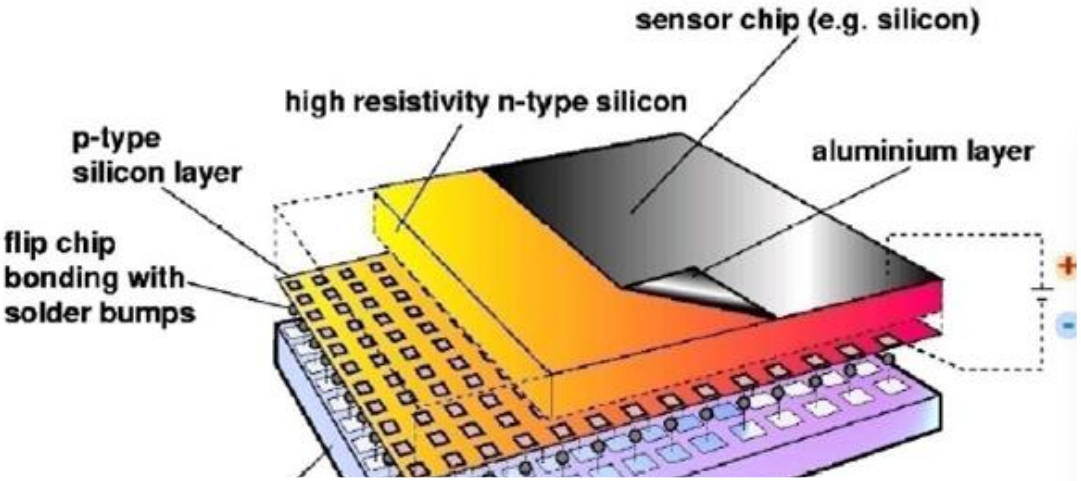
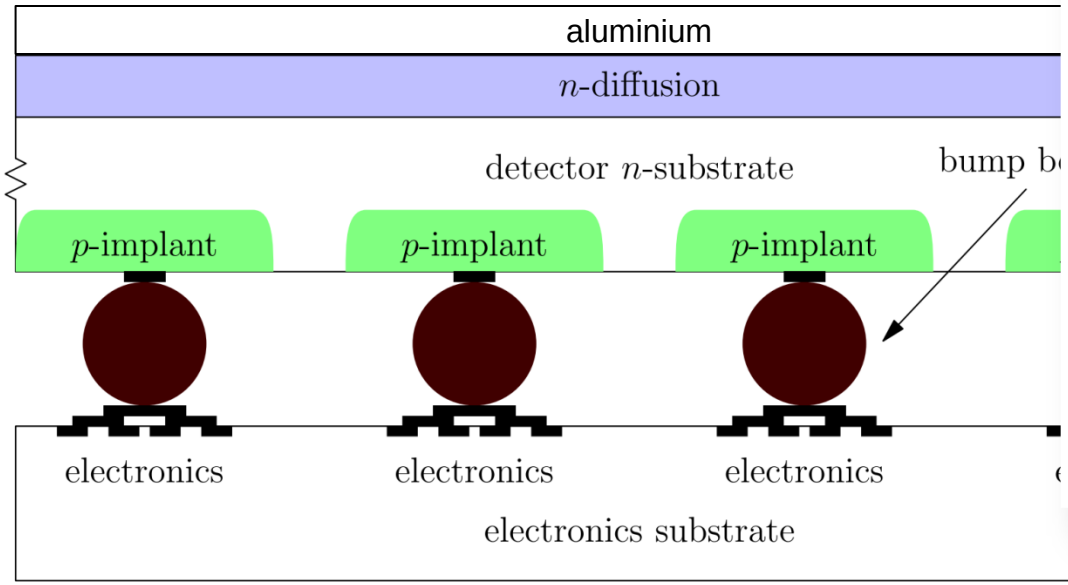
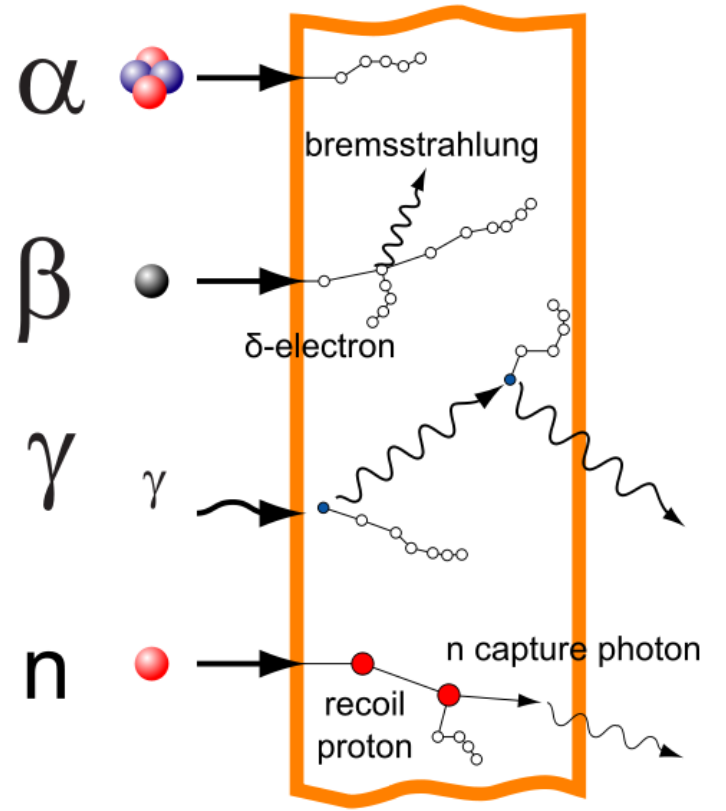
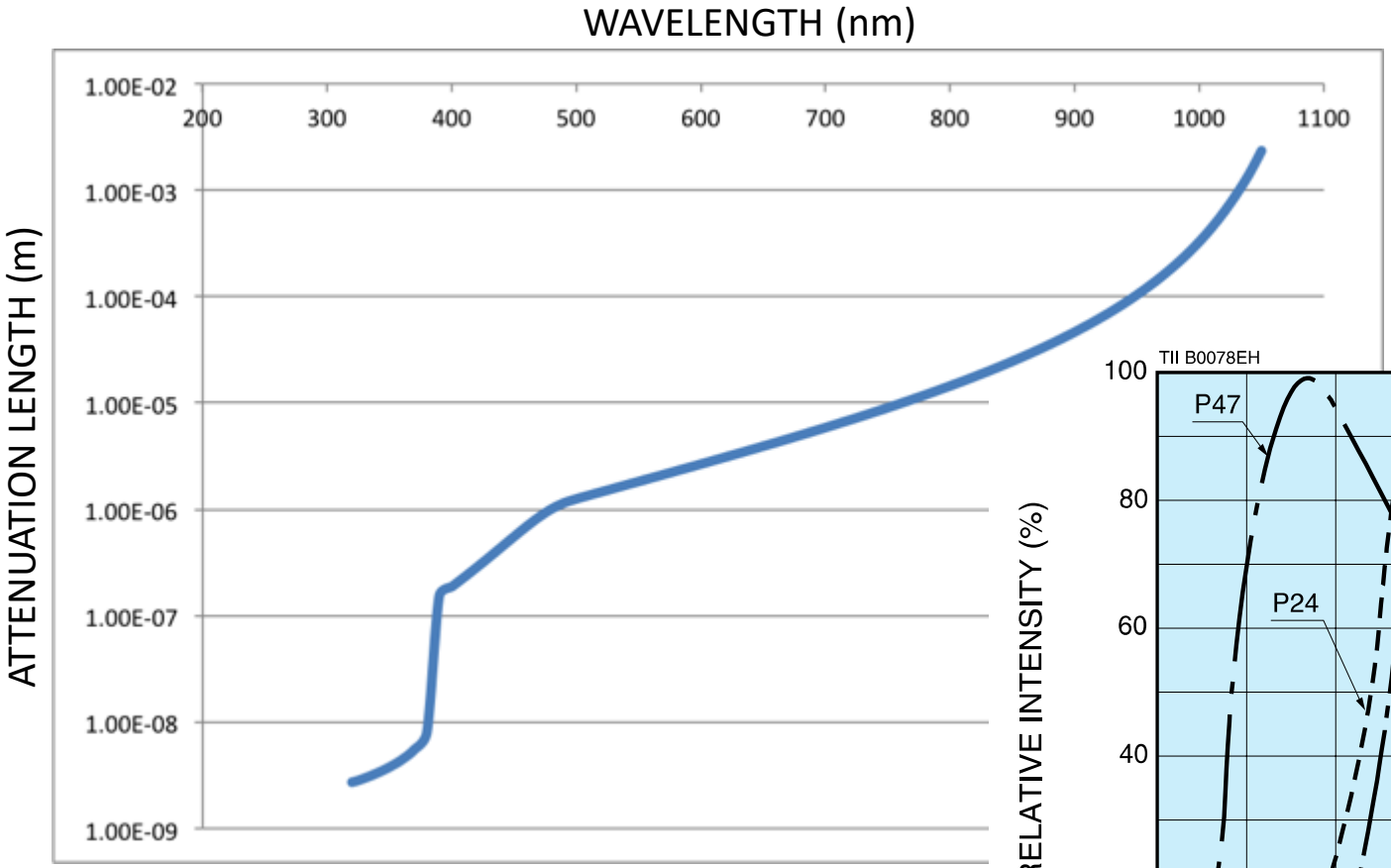
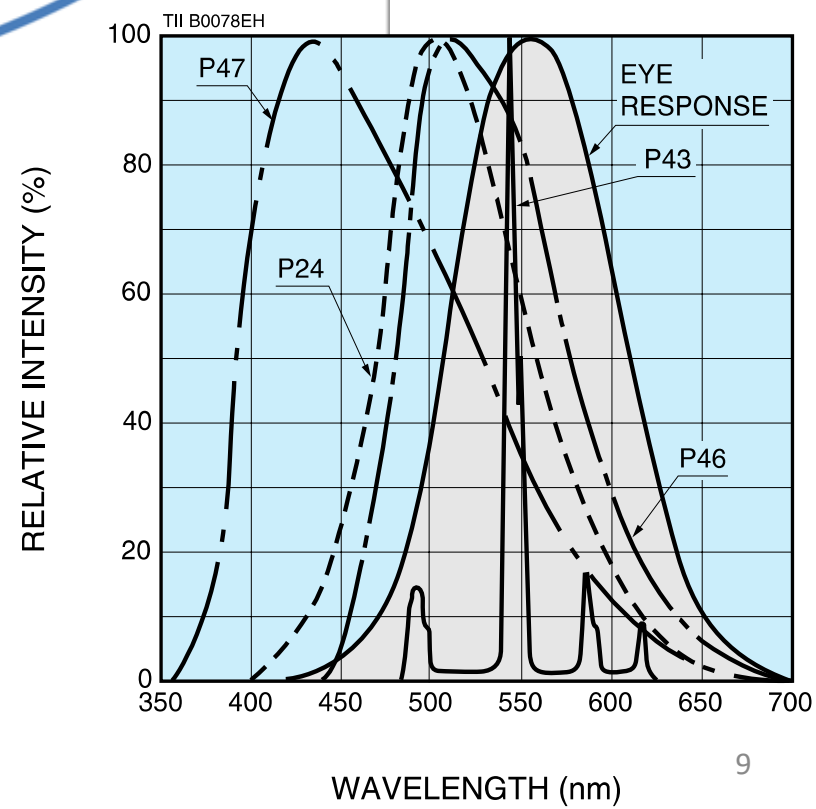






Photon absorption in Silicon





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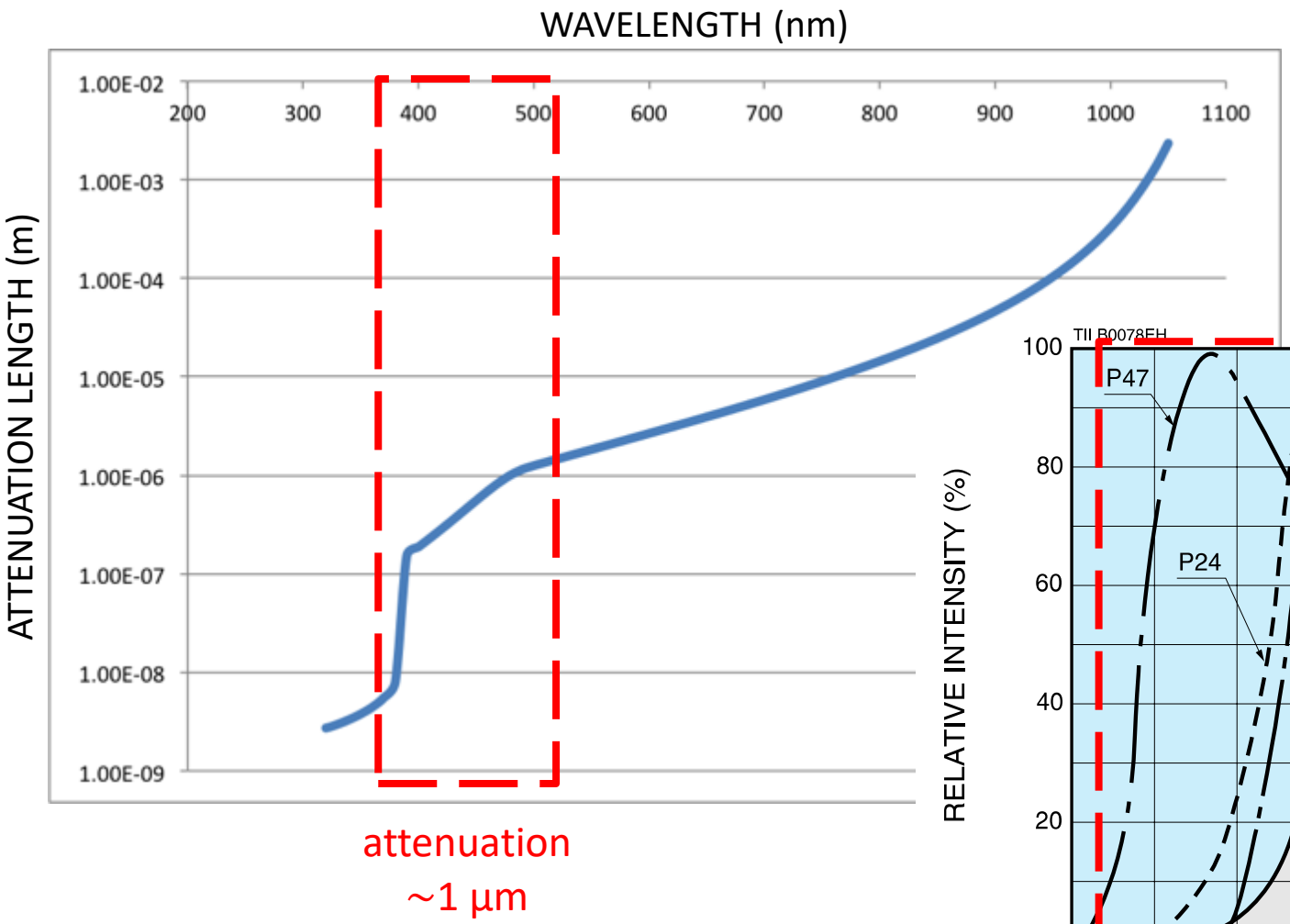
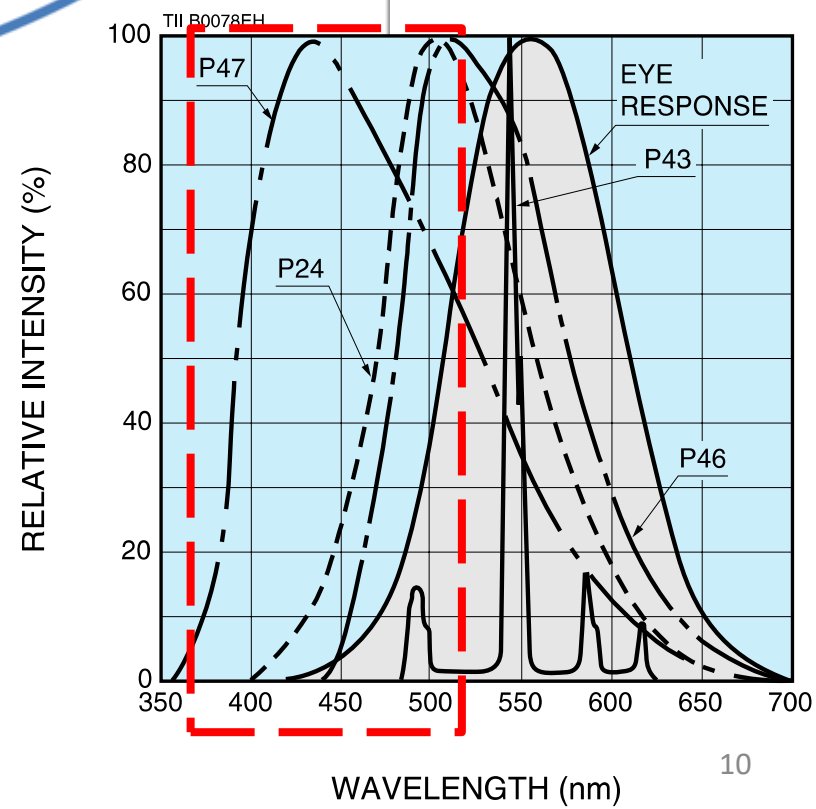
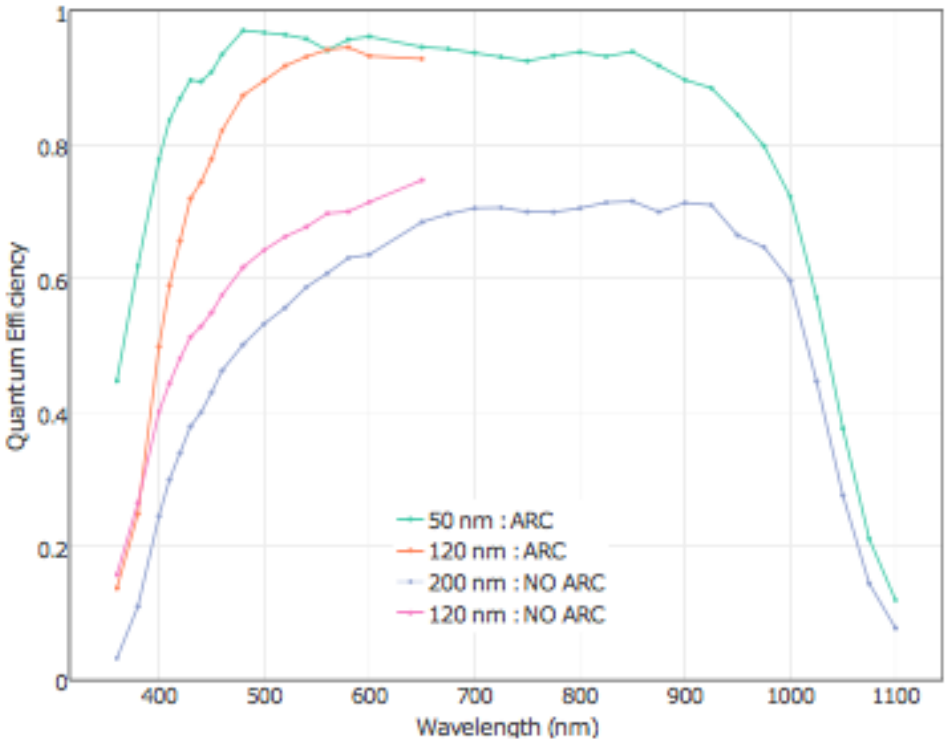
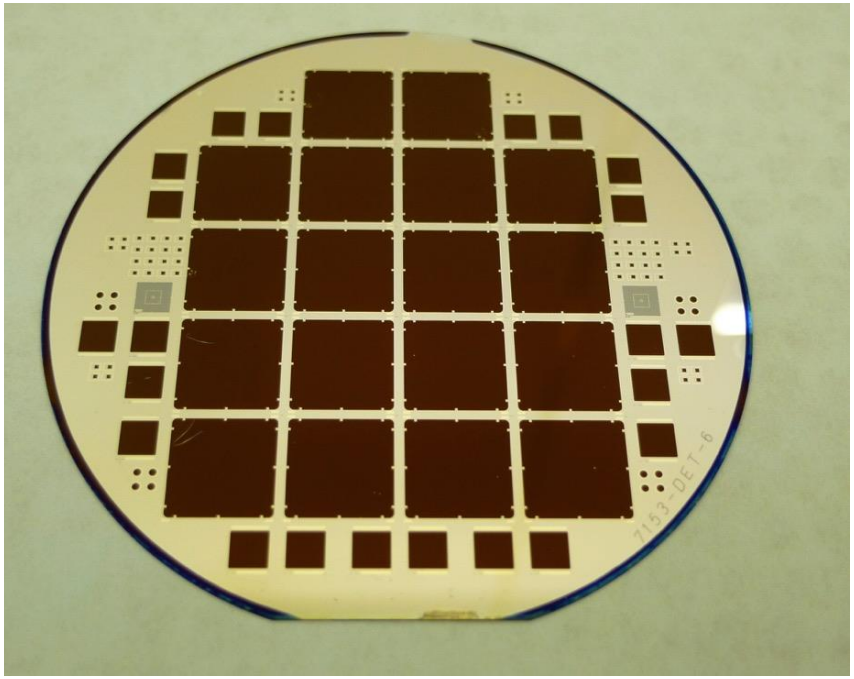




Quantum efficiency





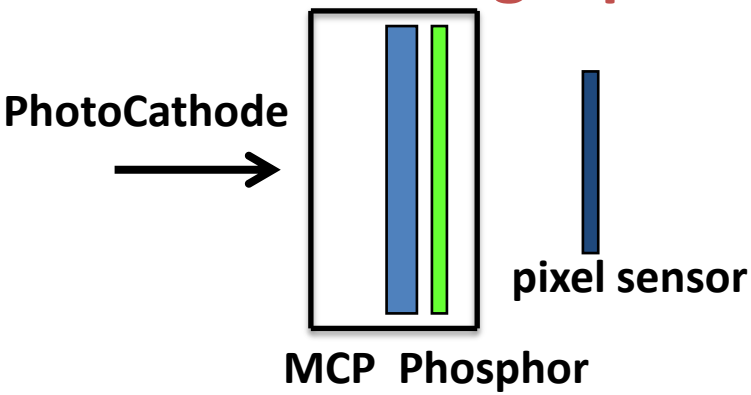
TimepixCam: a fast optical imager with time-stamping
M. Fisher-Levine, A. Nomerotski
Journal of Instrumentation 11 (03), C03016

Characterization of TimepixCam, a fast imager for the time-stamping of optical photons
A. Nomerotski, I. Chakaberia, M. Fisher-Levine, Z. Janoska, P. Takacs, ...
Journal of Instrumentation 12 (01), C01017

EXPERIMENT CONFIGURATION

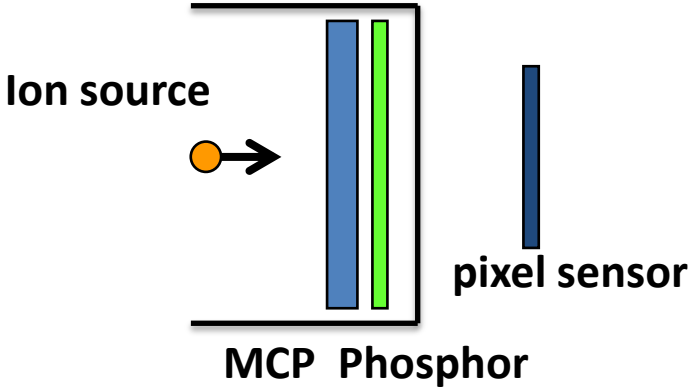
Configurations

Detection of single photons



Detection of ions

used for ion/electron/neutron imaging



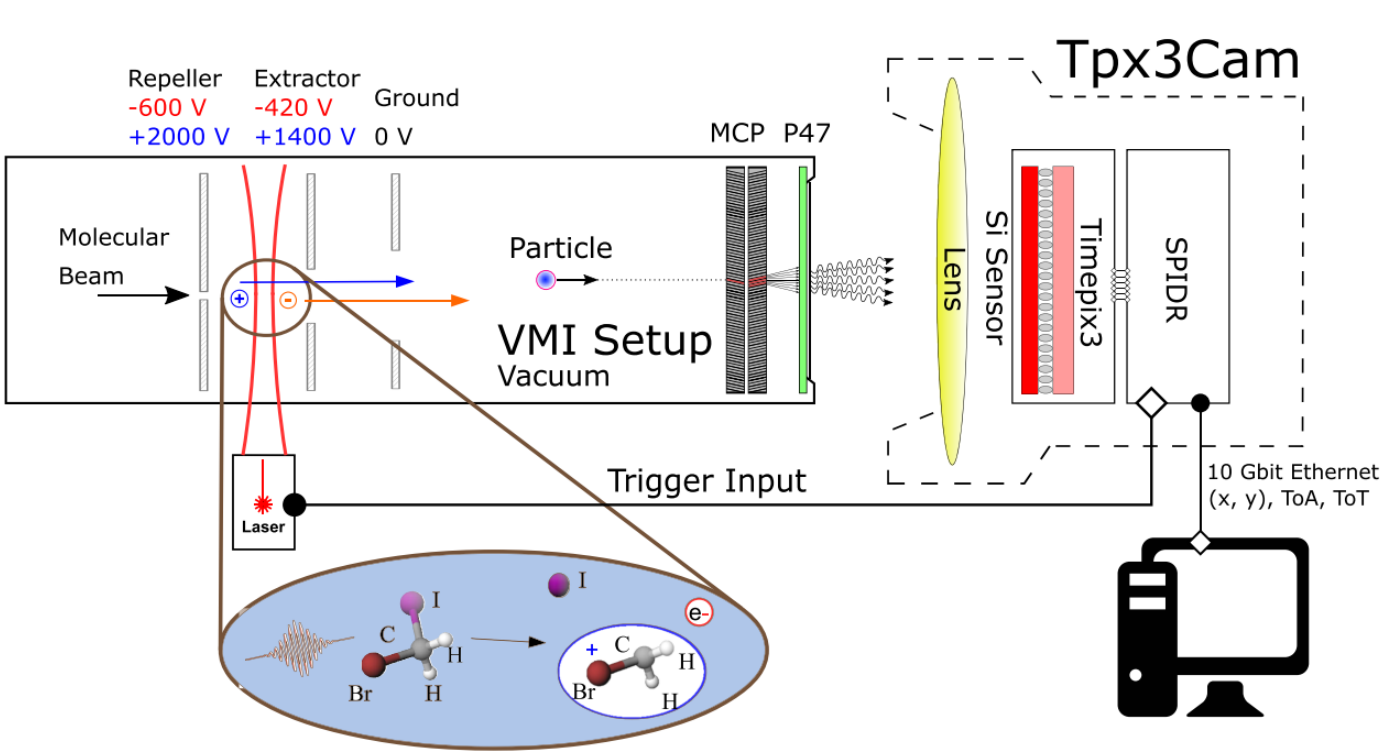
XRI-UNO, X-Ray Imatek

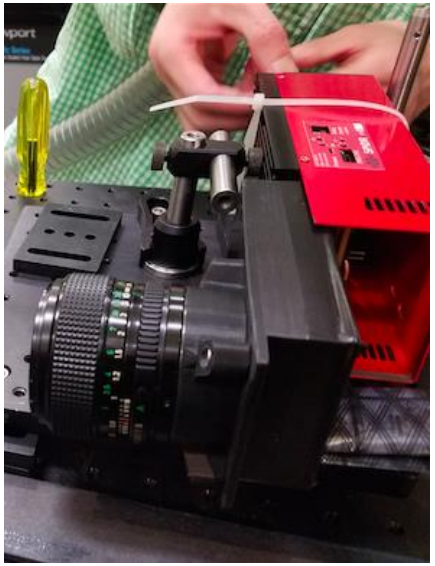
Photon counting phosphorescence lifetime imaging with TimepixCam

L. M. Hirvonen, M. Fisher-Levine, K. Suhling, and A. Nomerotski

Rev. Sci. Instrum. 88, 013104 (2017)

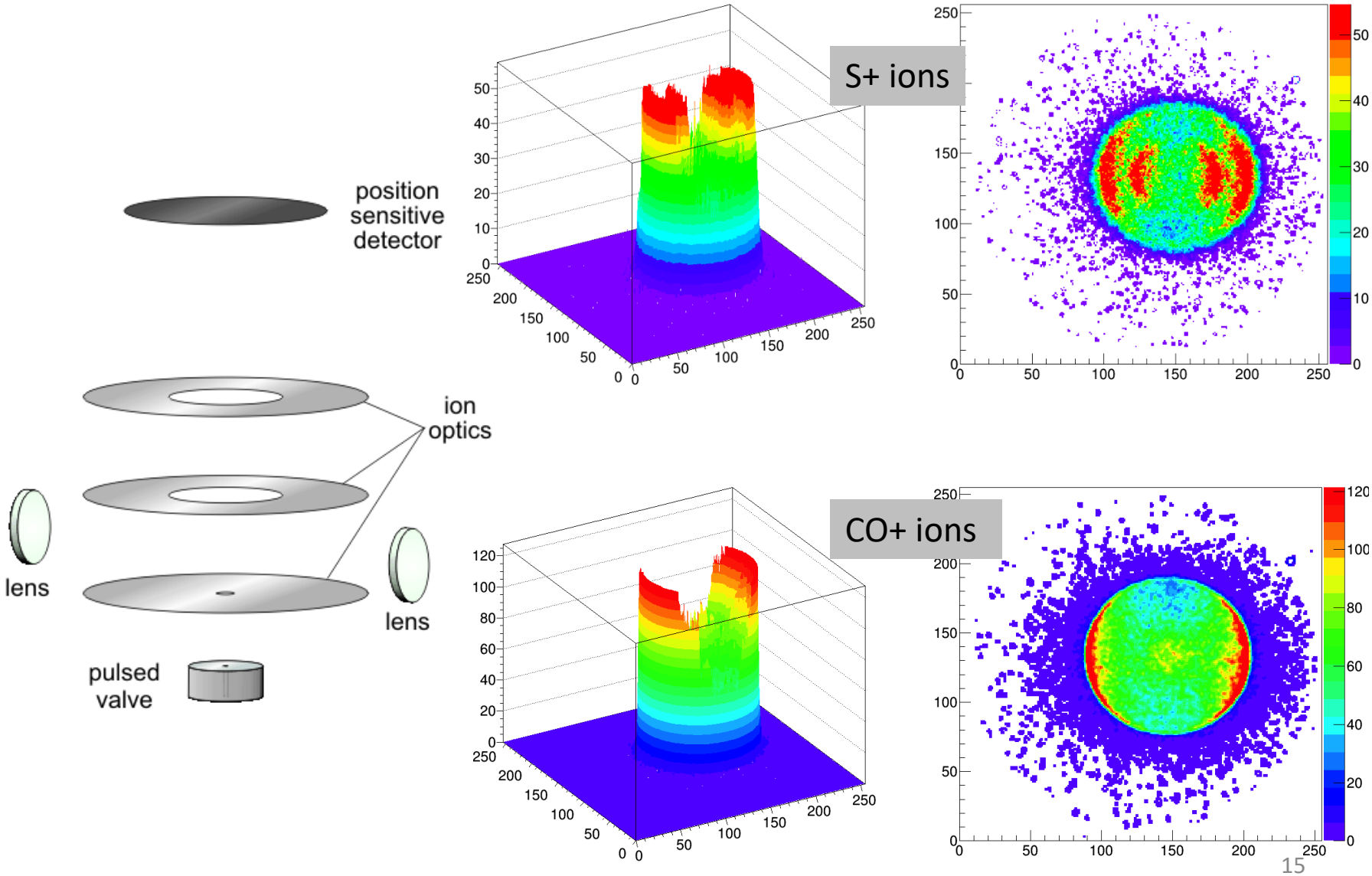
Tpx3Cam setup





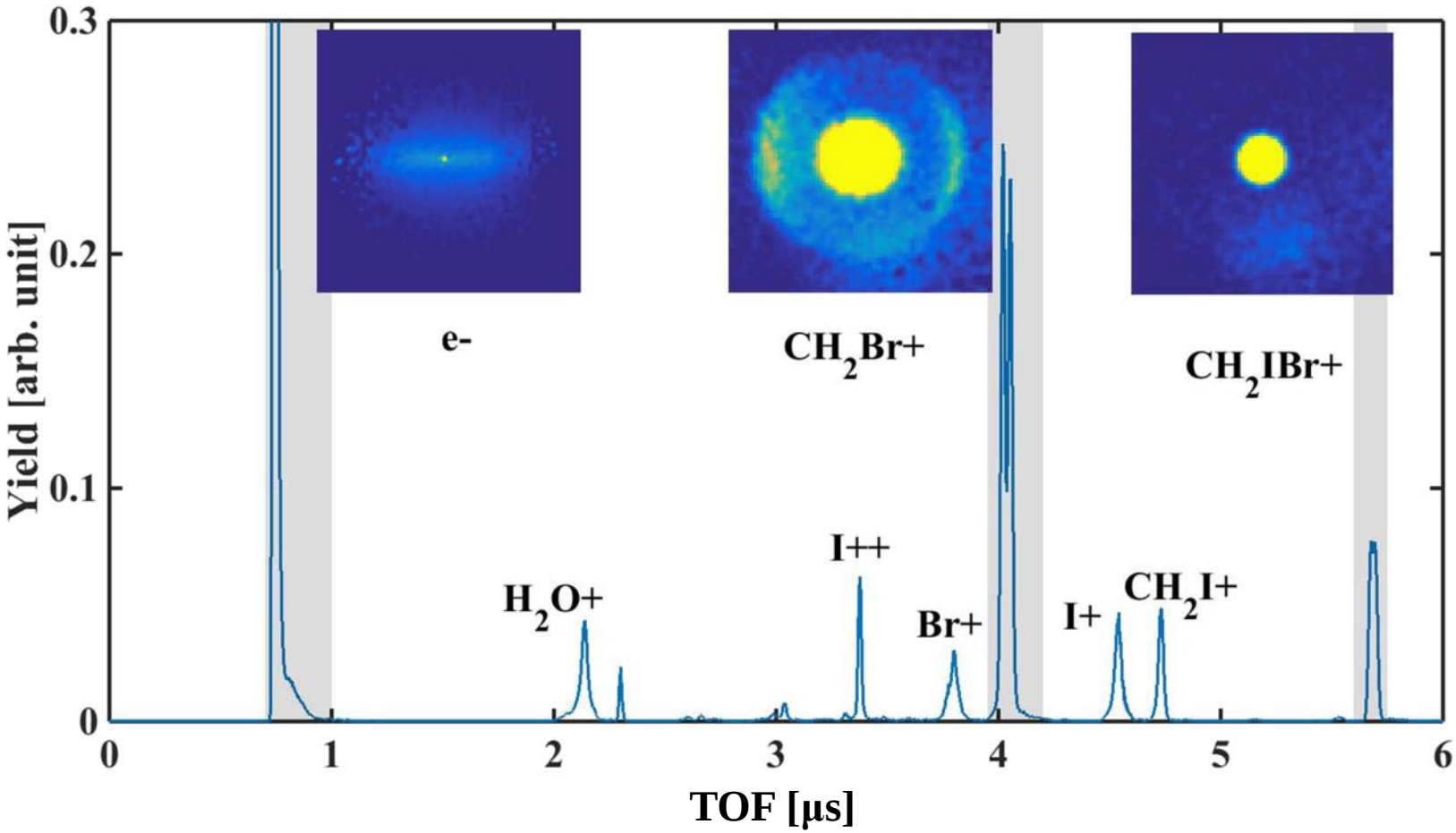
SPIDR readout	(**Nikhef, ASI**)
VMI experiments	(**SBU - Weinacht group**)

Velocity Map Imaging



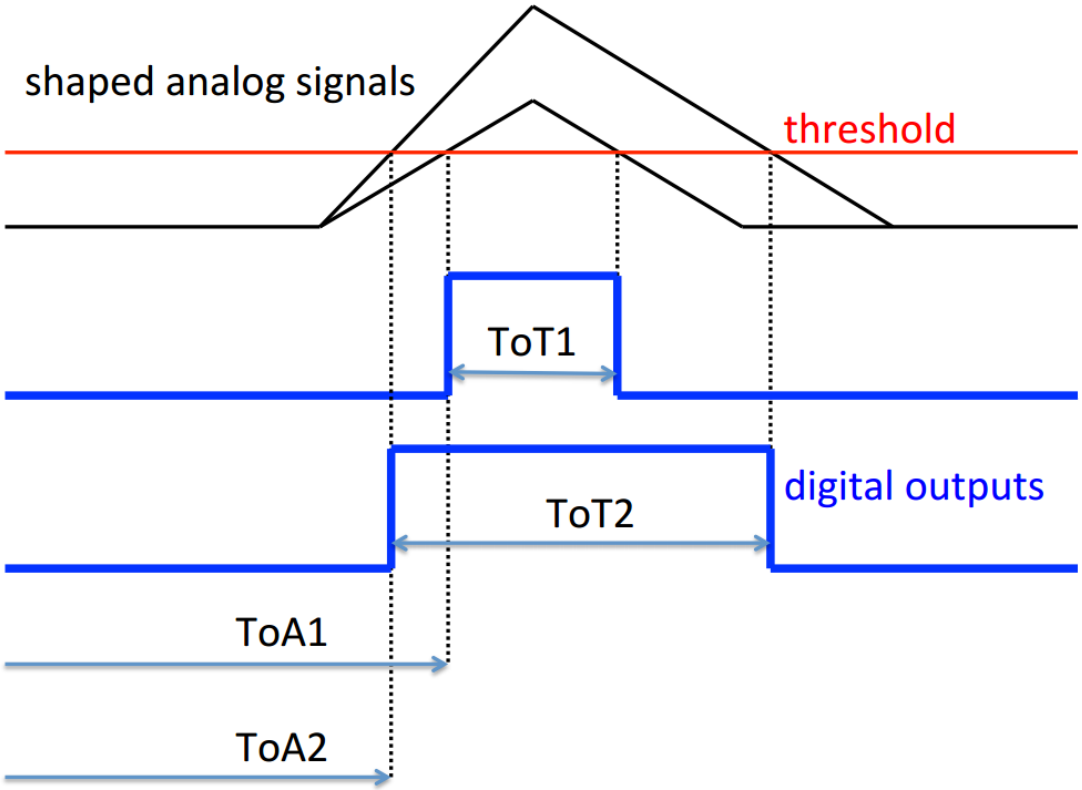
RESULTS AND CORRECTIONS

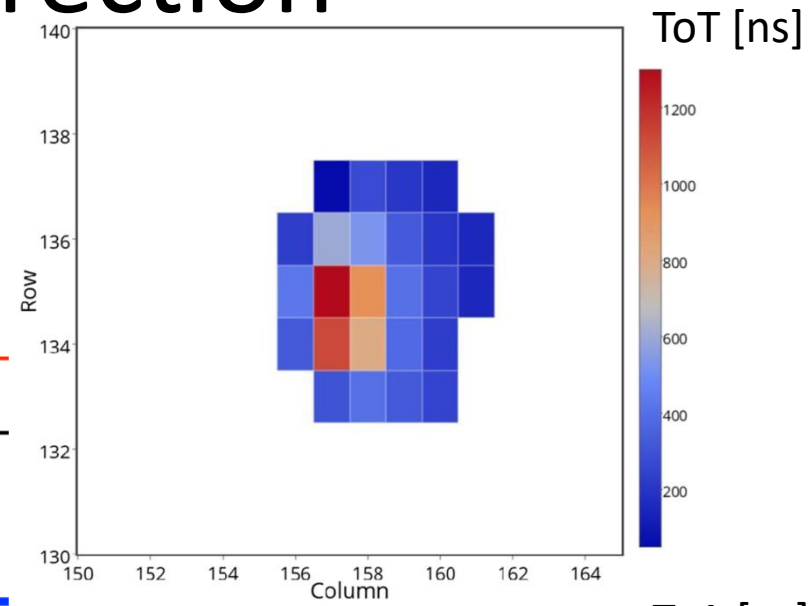
Results

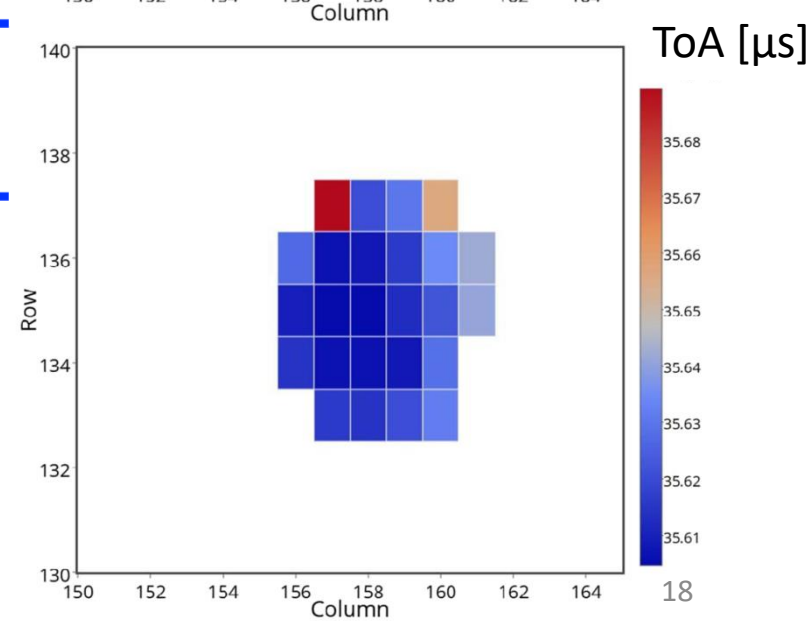


= ToA - TrigTime

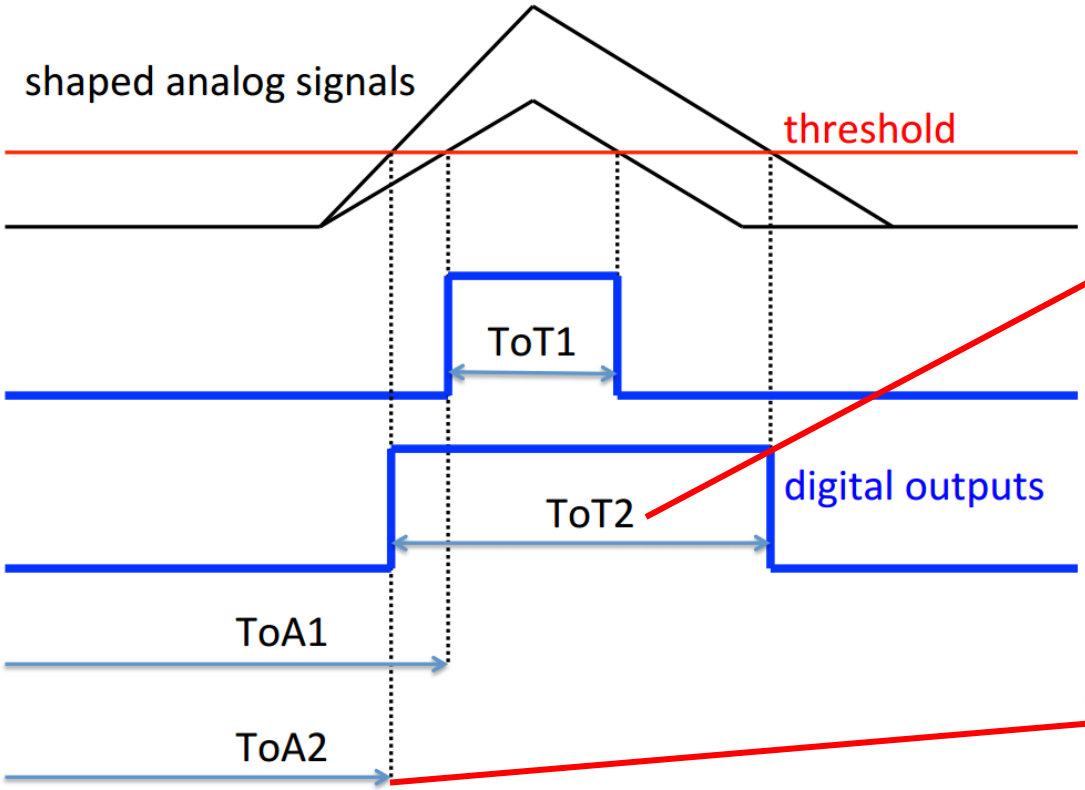
Timewalk correction

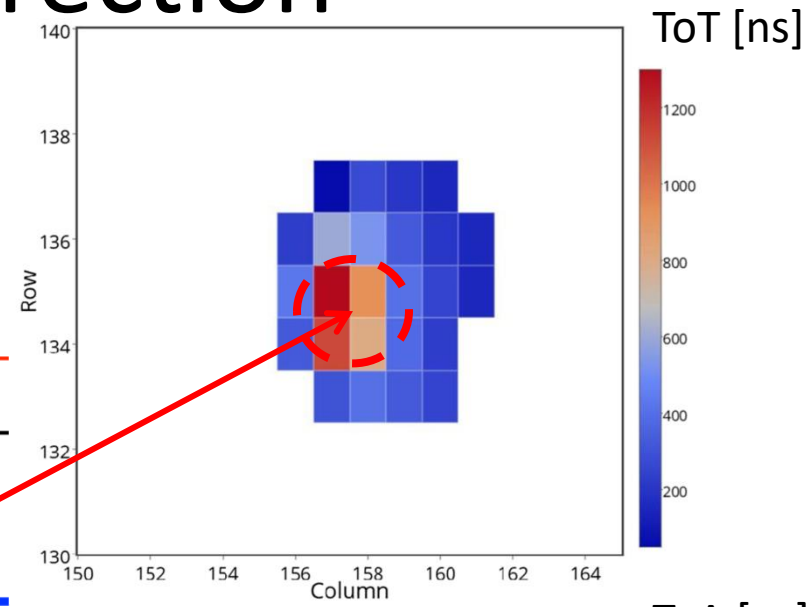


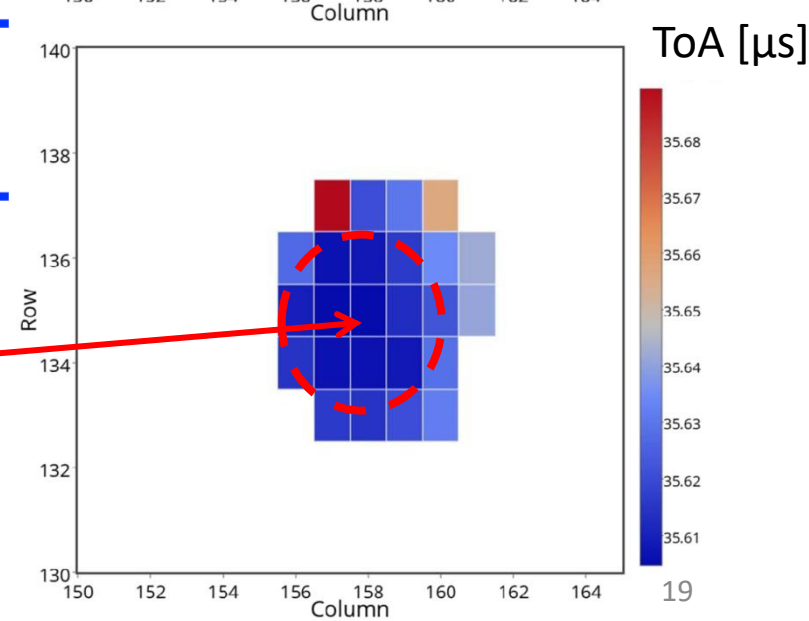




Timewalk correction







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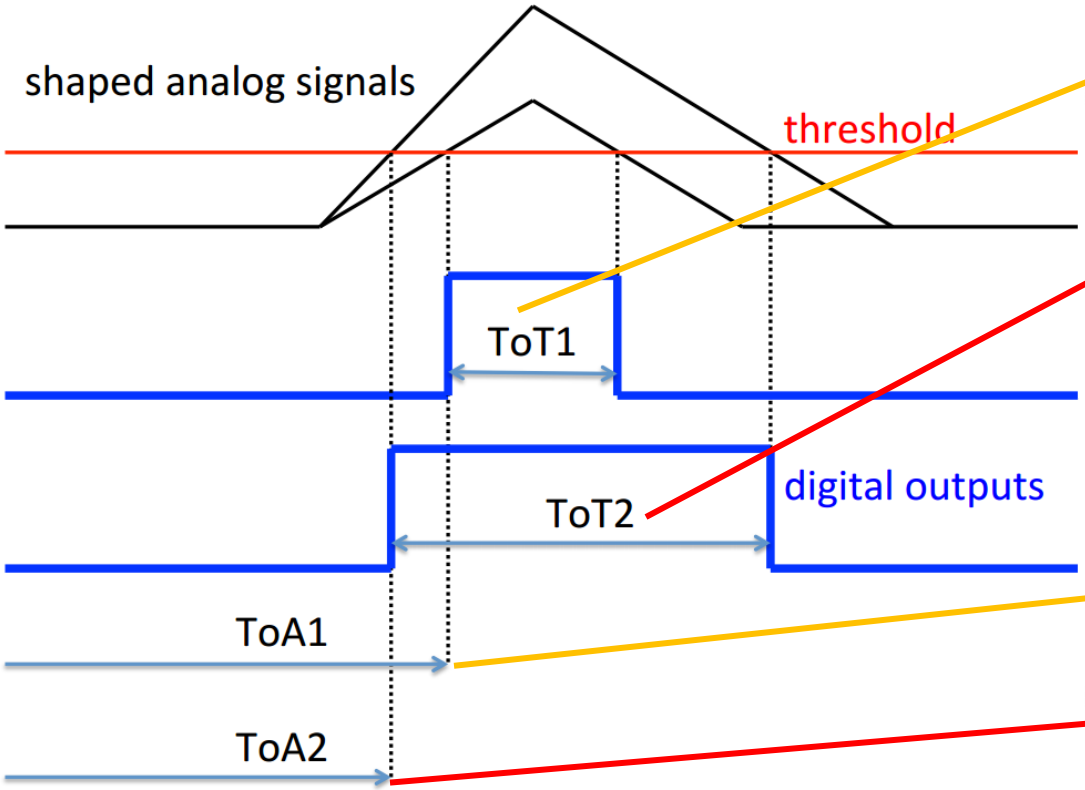
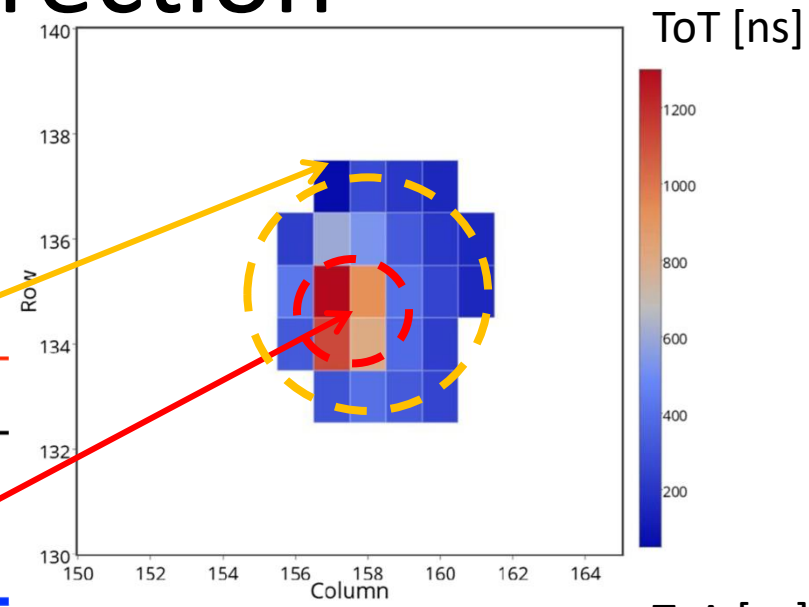
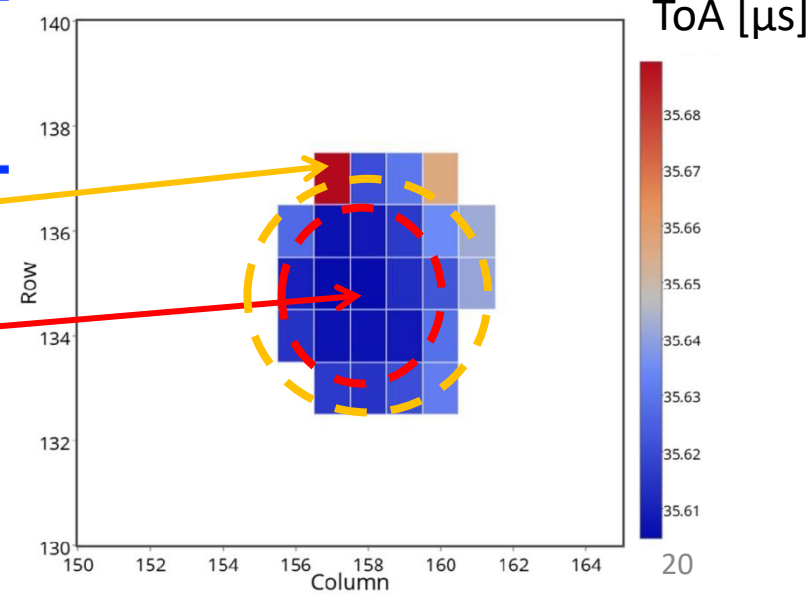


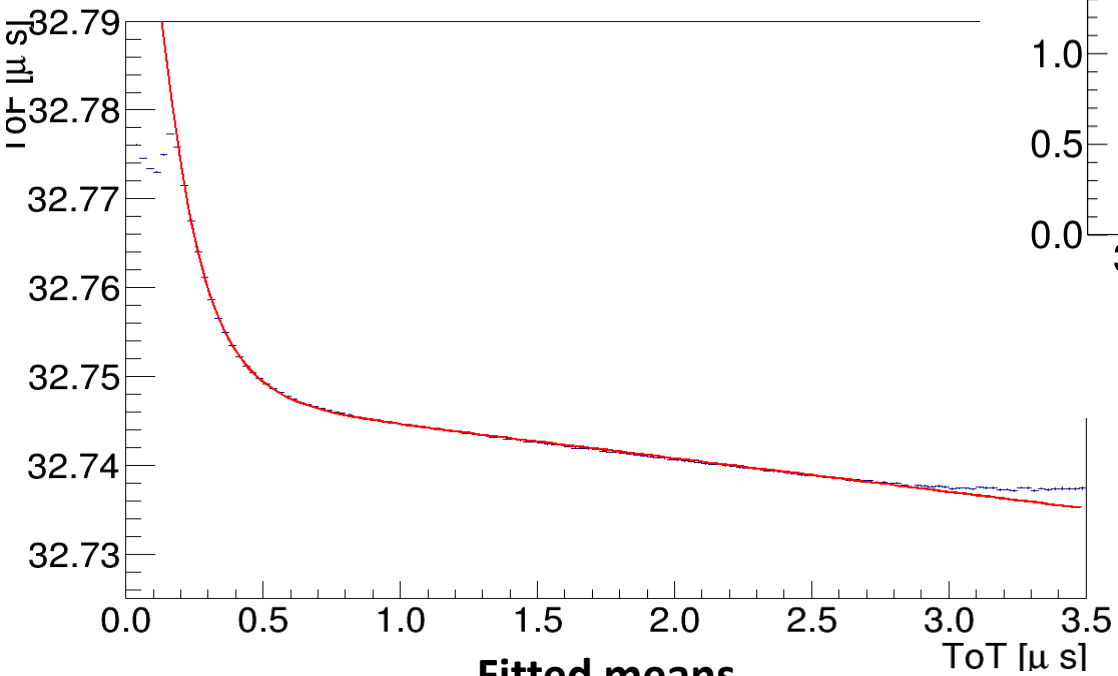




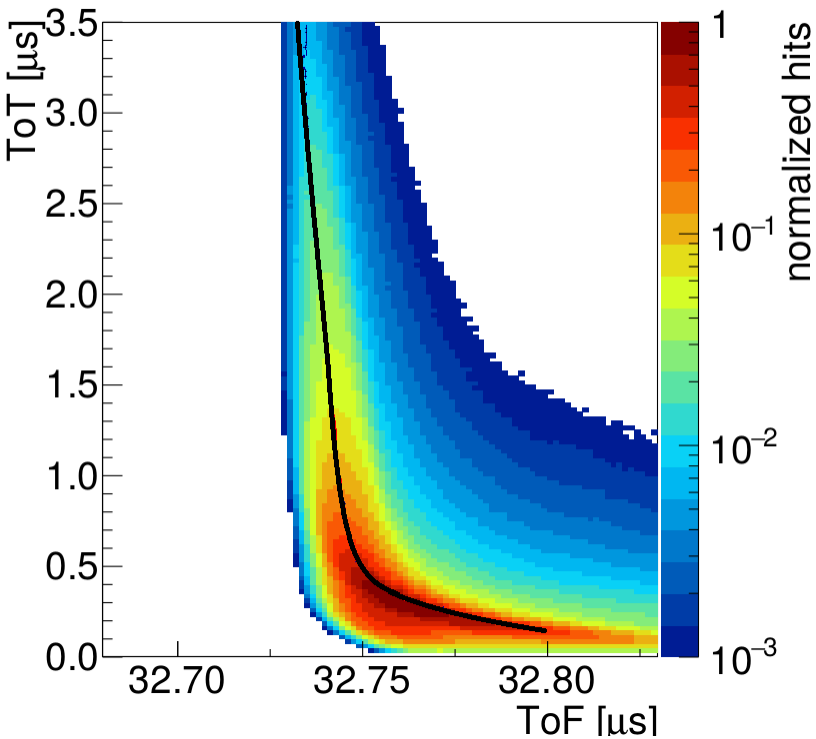
Timewalk algorithm

$$ToF = \mathrm{A} + \mathrm{B}\cdot ToT + \mathrm{C}\cdot\exp(\mathrm{D}\cdot ToT)$$

	Value	Error
A	3.27484e+01	6.21876e-06
B	3.77307e-03	4.01281e-06
C	1.13120e-01	1.14984e-04
D	7.31393e+00	4.61065e-03



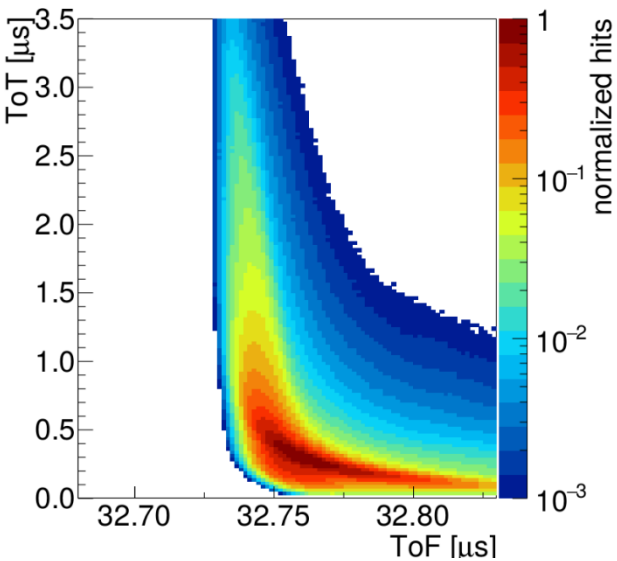
Fitted means



Raw data

Data improvement

- Electron mass peak from the spectrum
  - ToT vs ToF correlation



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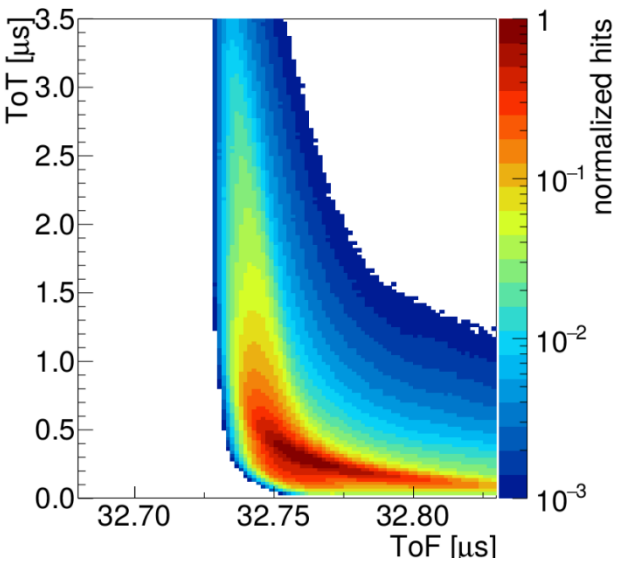

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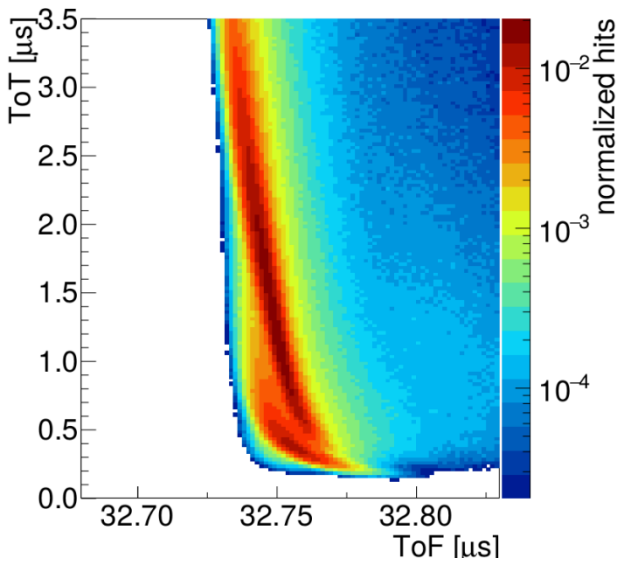
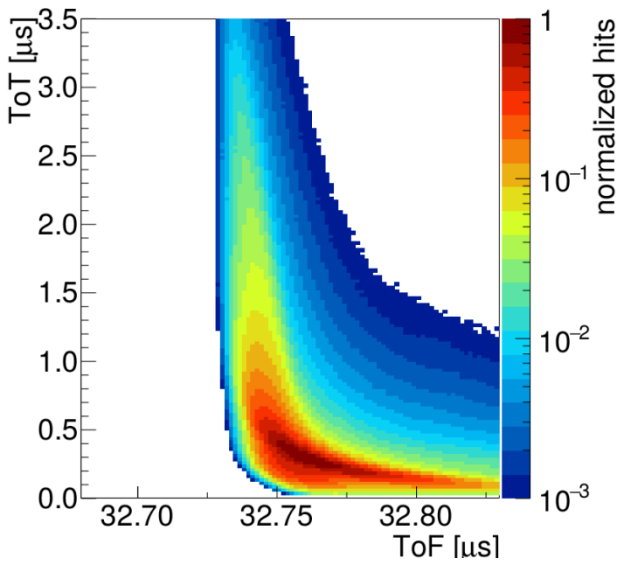


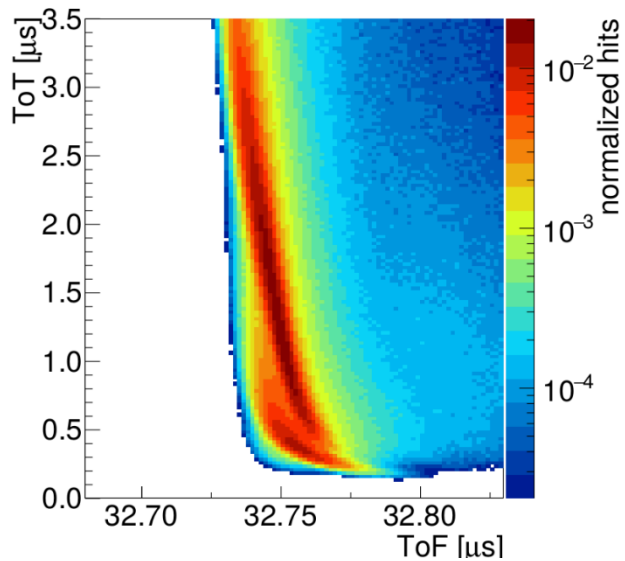
Centroid data

Data improvement

- Electron mass peak from the spectrum
  - ToT vs ToF correlation



Raw data



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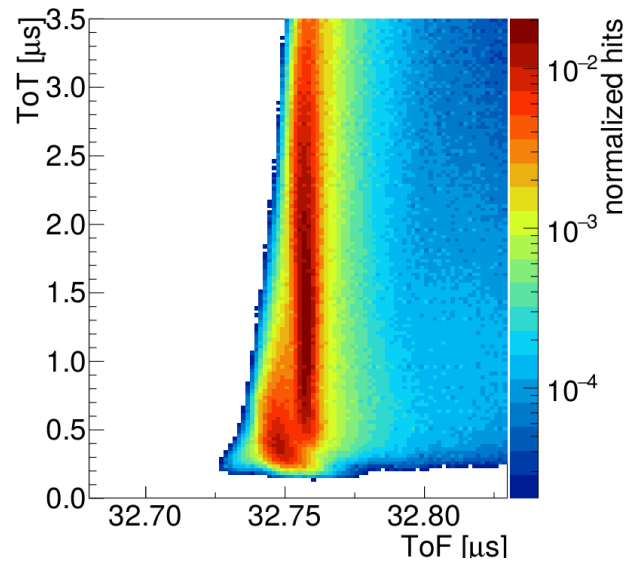
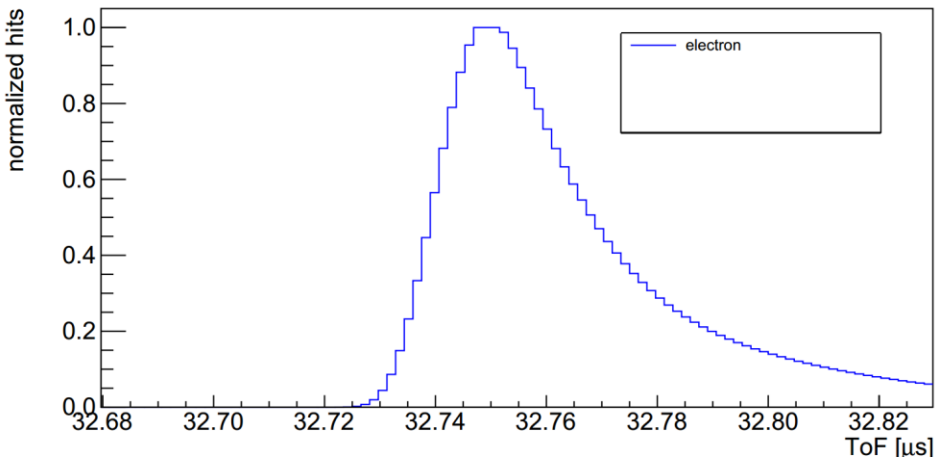


Centroid & timewalk data

Data improvement



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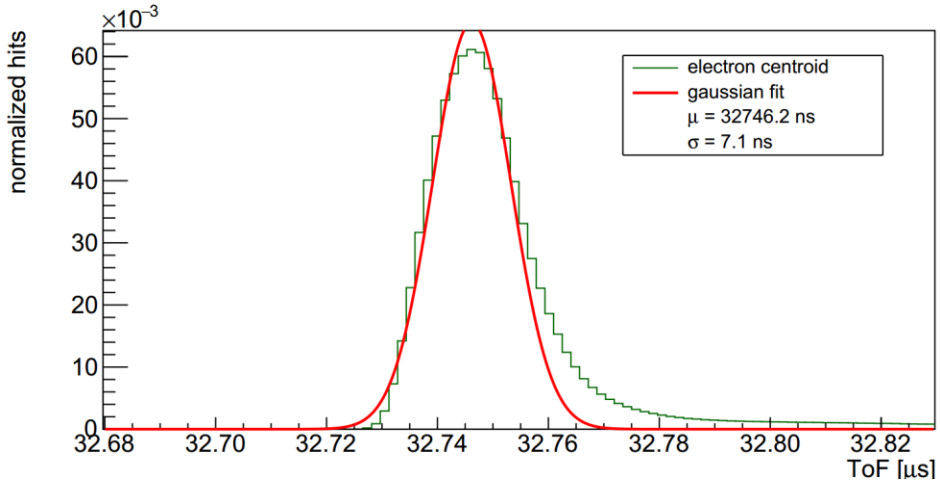
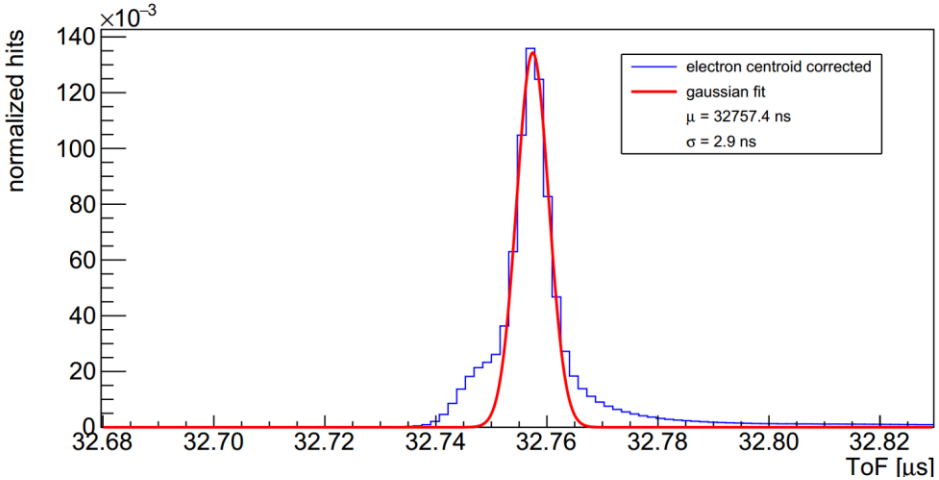
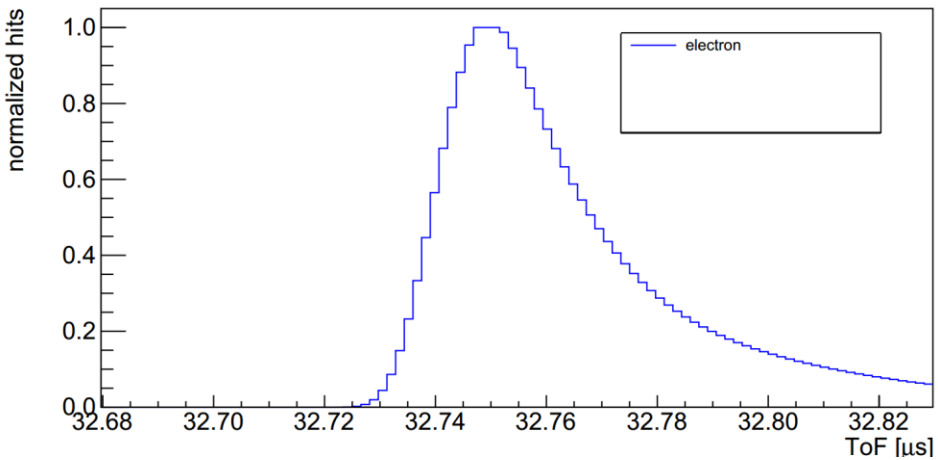


Centroid data



Centroid & timewalk data

Data improvement



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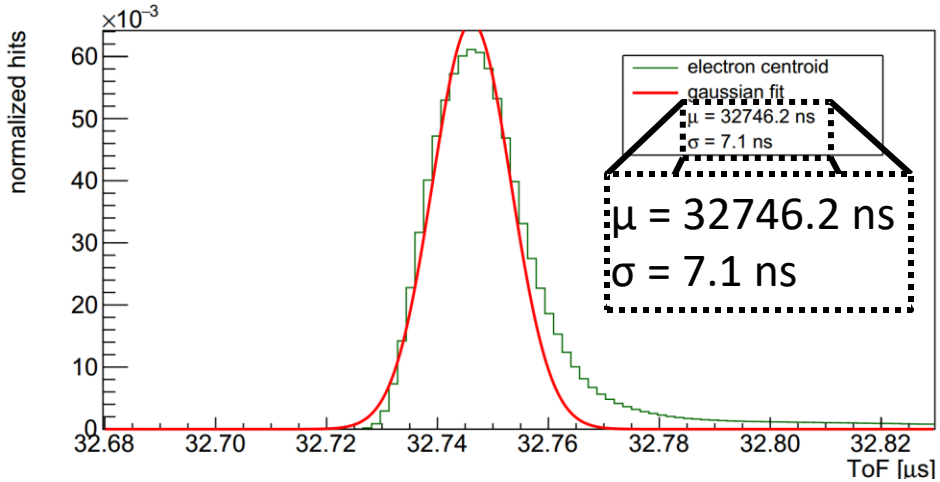

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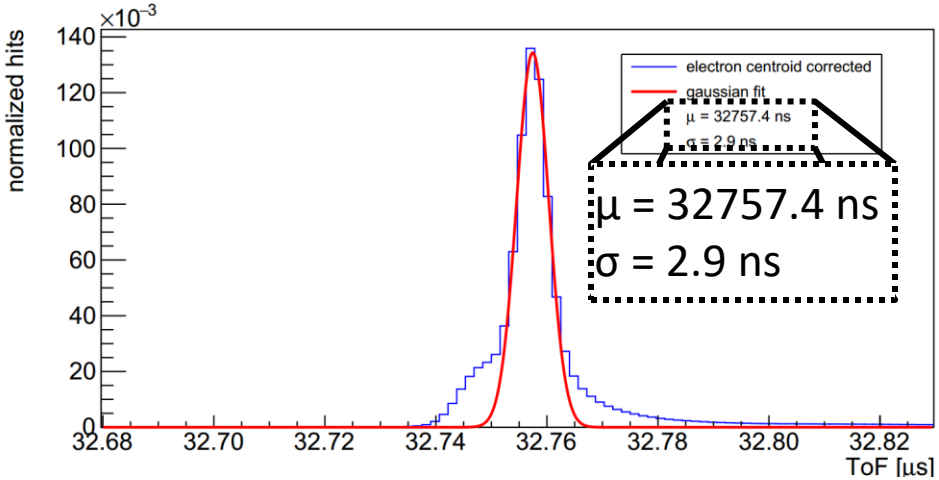

Centroid & timewalk data

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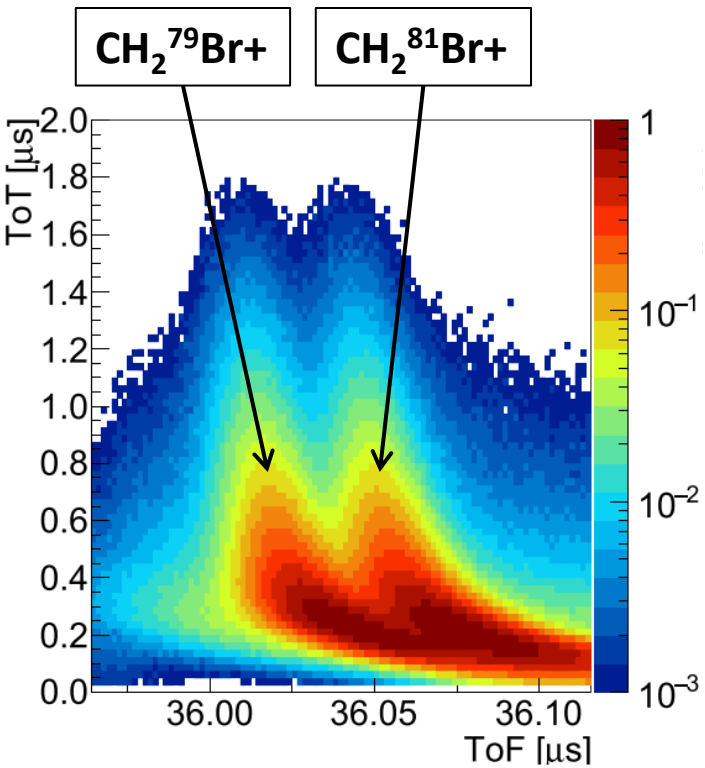

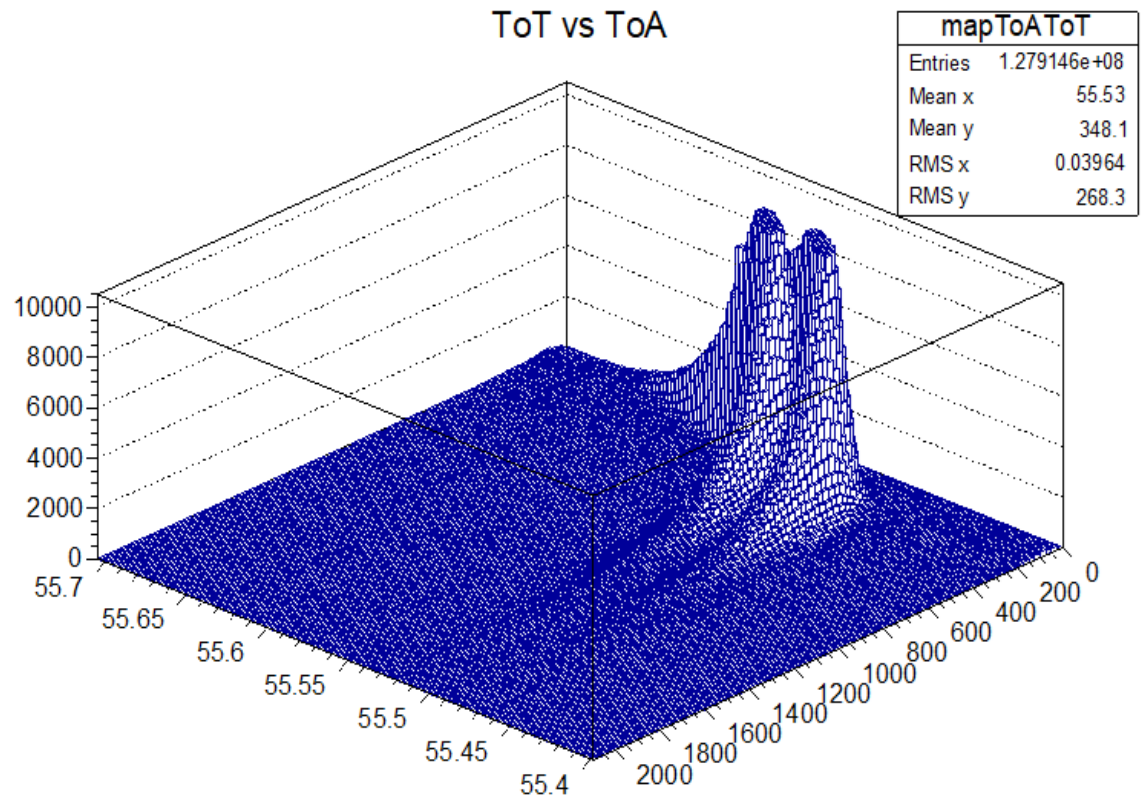

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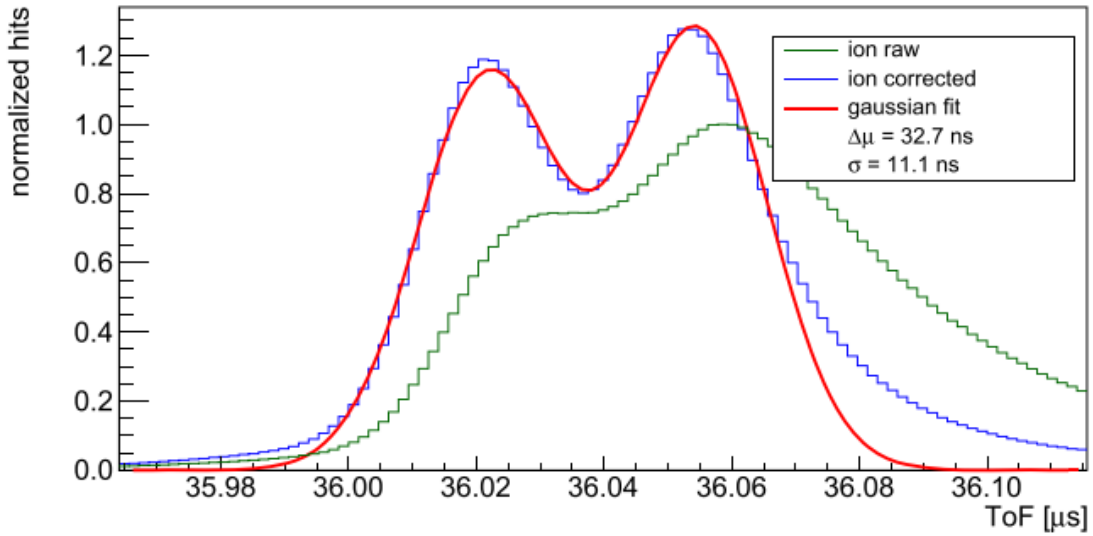
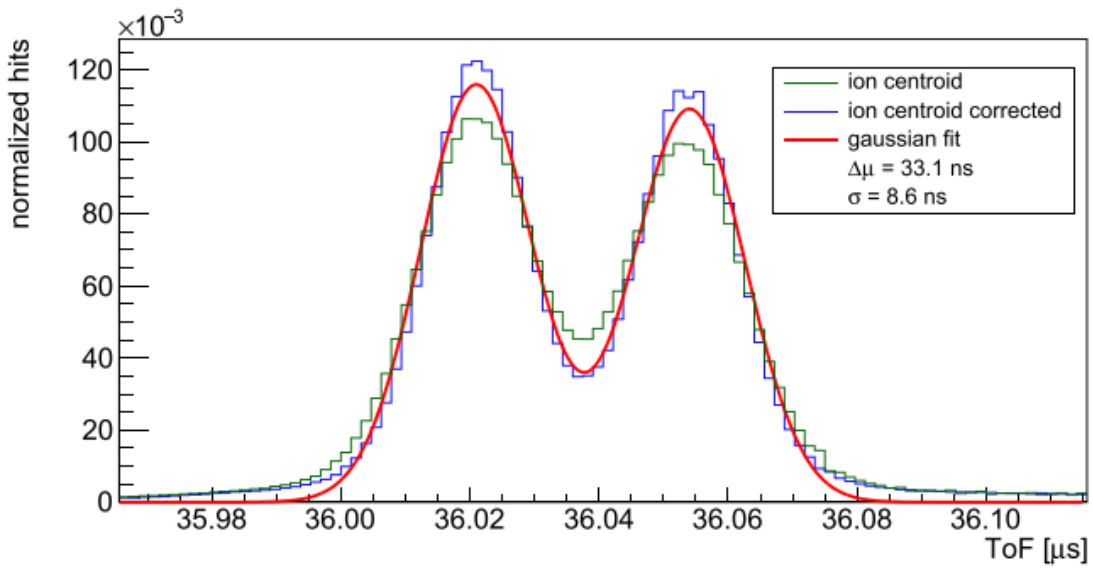
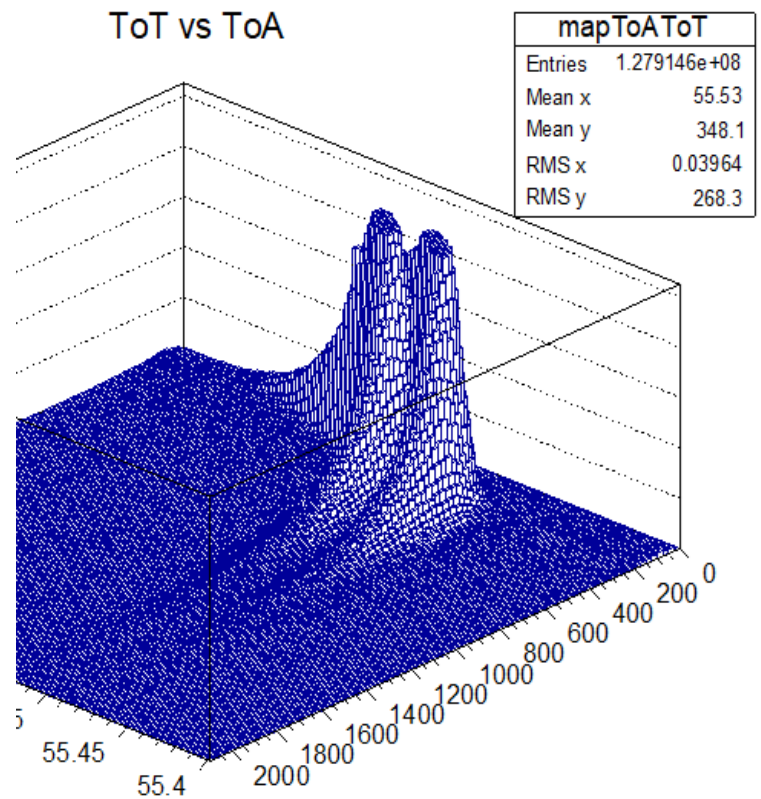
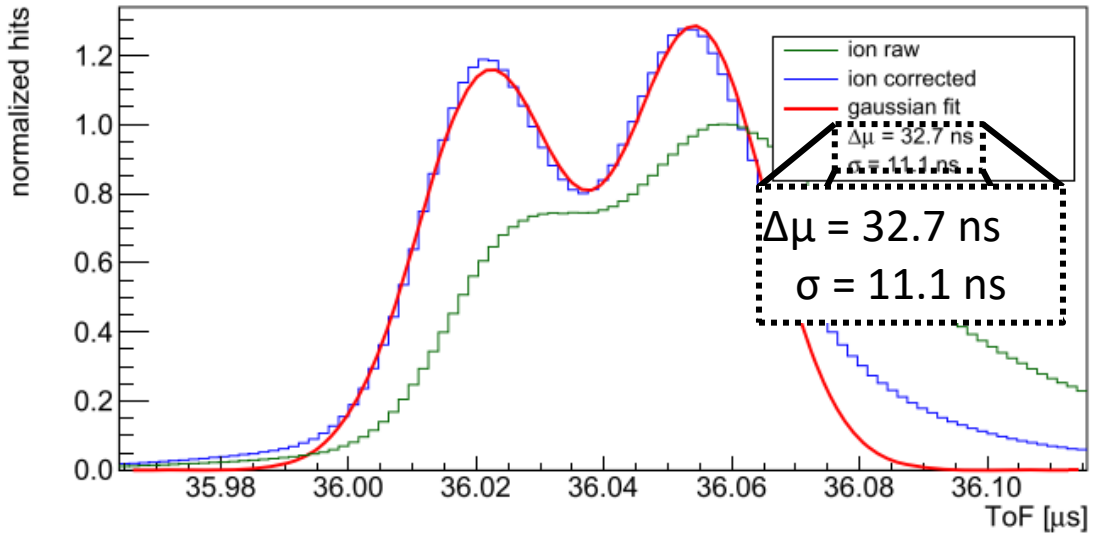
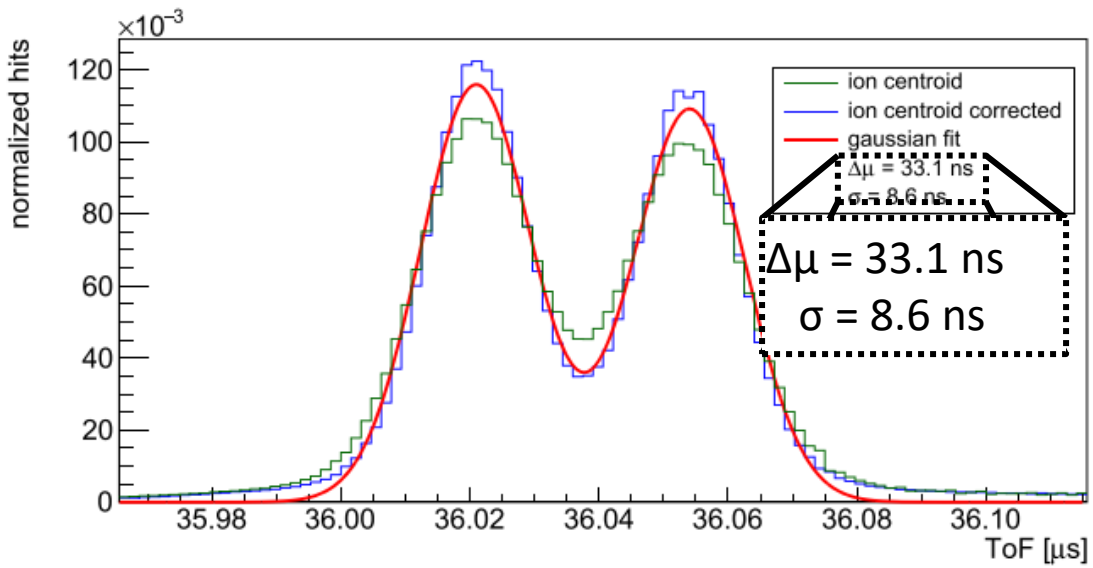


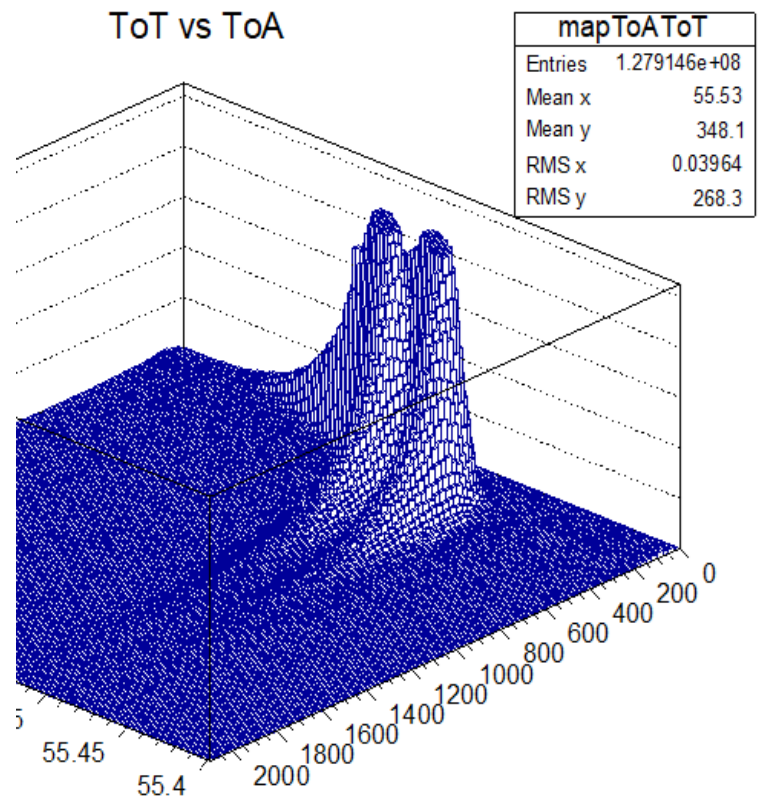




Data improvement

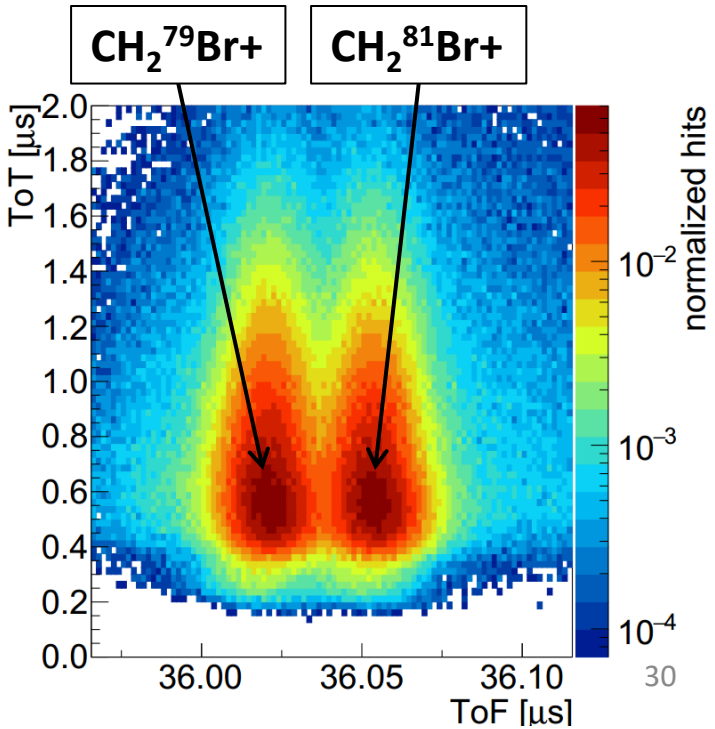






Conclusions

- Lot of groups interested in the fast detection of optical photons
  - Increasing number of applications (VMI, entanglement, ...)
- Precision after all corrections order of ns – possible improvement
  - Tpx3 contribution
  - P47 rise time (7-8 ns)
  - Ion source time jitter
- Reaching maximal Timepix3 precision



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